

CLAIMS

1        1.        A method for transmitting a plurality of pre-coded programs having different bit  
2 rates across a fixed bandwidth channel, comprising the steps of:

3            generating at least two different bit rate representations of each program;

4            providing control information at each of a plurality of successive time windows T for  
5 each representation of each program, the control information for each successive window  
6 indicating a bit rate and quality measure for a representation of a corresponding program; and

7            during each time window T, selecting a representation for each program such to  
8 maximize the quality of the selected representations while not exceeding a total available  
9 capacity for the channel.

1            2.        The method according to claim 1 wherein the step of generating at least two  
2 different bit rates representation further comprises the step of generating for each program a  
3 lowest bit rate representation having a peak bit rate not greater than  $C/P$  where  $C$  is the total  
4 channel capacity in time T and  $P$  is the total number of programs.

1            3.        The method according to claim 1 wherein the step of providing the control  
2 information further comprises the step of establishing the peak signal-to-noise ratio (PSNR) as  
3 the quality measure embodied in the control information.

1            4.        The method according to claim 1 wherein the selecting step further comprises the  
2 step of selecting a representation for each program which meets the constraint

3             $\sum_{p=0}^{P-1} r[p, n[p]] \leq C$  for all time windows wherein:

4             $C$  is the total channel capacity available in time frame T;

5             $P$  is the total number of programs;

6             $p \in (0, P-1)$ , is the index of a particular program;

7             $N[p]$  is the total number of representations of program  $p$ ;

8             $n[p] \in (0, N[p] - 1)$  is the index of a particular representation of program  $p$ ; and

9             $r[p, x]$  is the bit rate of representation  $x$  of program  $p$  during T

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1           5.       The method according to claim 4 further comprising the step of choosing each  
2       program's representation  $n[p] \in (0, N[p]-1)$  to maximize the quality of the program  $p$  that had  
3       the minimum quality.

1           6.       The method according to claim 5 further comprising the steps of:  
2           (a) sorting the quality information for with the bit rate and quality measure monotonically  
3       increasing with an index value;  
4           (b) storing each bit rate increment (delta) and quality value for each index value;  
5           (c) beginning with a lowest index value, computing total capacity  $S$  for program  
6       representations selected thus far for such index value;  
7           (d) selecting a program representation at a lowest quality measure;  
8           (e) checking whether the bit rate increment of the selected program at the lowest quality,  
9       when added to the representations selected thus far, exceeds total channel capacity, and if not  
10          (f) incrementing the index value; and  
11          (g) repeating steps (c)-(f).

1           7.       The method according to claim 1 wherein the selecting step further comprises the  
2       step of selecting the representation for each program such to maximize a sum of individual

3       program qualities by solving  $\max_{n[p]} \sum_{p=0}^{P-1} q[p, n[p]]$ ; subject to  $\sum_{p=0}^{P-1} r[p, n[p]] \leq C$

4       wherein ,

5        $C$  is the total channel capacity available in time frame  $T$ ;

6        $P$  is the total number of programs;

7        $p \in (0, P-1)$ , is the index of a particular program;

8        $N[p]$  is the total number of representations of program  $p$ ;

9        $n[p] \in (0, N[p]-1)$  is the index of a particular representation of program  $p$ ;

10       $r[p, x]$  is the bit rate of representation  $x$  of program  $p$  during  $T$ ; and

11       $q[p, x]$  is the quality of representation  $x$  of program  $p$  during  $T$ .

1           8.       The method according to claim 1 wherein the selecting step further comprises the  
2       step of selecting the representation for each program such to maximize a product of individual  
3       program qualities by solving

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$$\max_{n[p]} \prod_{p=0}^{P-1} q[p, n[p]]; \text{ subject to } \sum_{p=0}^{P-1} r[p, n[p]] \leq C$$

5 where,

6  $C$  is the total channel capacity available in time frame  $T$ ;

7  $P$  is the total number of programs;

8  $p \in (0, P-1)$ , is the index of a particular program;

9  $N[p]$  is the total number of representations of program  $p$ ;

10  $n[p] \in (0, N[p] - 1)$  is the index of a particular representation of program  $p$ ;

11  $r[p, x]$  is the bit rate of representation  $x$  of program  $p$  during  $T$ ; and

12  $q[p, x]$  is the quality of representation  $x$  of program  $p$  during  $T$ .

1           9.     The method according to claim 8 further comprising the step of applying a  
2 weighted average to provide different classes of service for different viewers.

1           10.    A system for transmitting a plurality of pre-coded programs having different bit  
2 rates across a fixed bandwidth channel, comprising the steps of:  
3           means for generating at least two different bit rate representations of each program;  
4           means providing control information at each of a plurality of successive time windows  $T$   
5 for each representation of each program, the control information for each successive window  
6 indicating a bit rate and quality measure for a representation of a corresponding program; and  
7           means for selecting during each time window  $T$  a representation for each program such to  
8 maximize the quality of the selected representations while not exceeding a total available  
9 capacity for the channel.

1           11.    The system according to claim 10 wherein the generating means and control  
2 information providing means collectively comprise:  
3           a plurality of multirate stream generators, each associated with a corresponding one of the  
4 plurality of pre-coded programs.

1           12.    The system according to claim 10 wherein the generating means and control  
2 information providing means collectively comprise:  
3           a multirate video encoder for encoding at least two bit rate representations of each pre-  
4 coded program.

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1           13.    The system according to claim 10 wherein the generating means and control  
 2 information providing means collectively comprise:  
 3           a multirate video encoder for encoding at least two bit rate representations of each pre-  
 4 coded program; and  
 5           a plurality of transport packetizers, each serving to packetize the bit rate presentations for  
 6 each pre-coded program.

1           14.    The system according to claim 10 wherein the selecting means includes a static  
 2 multiplexer.

1           15.    The system according to claim 12 wherein the selecting means comprises:  
 2 a static multiplexer; and  
 3 a transport packetizer for packetizing the selecting representation.

1           16.    The system according to claim 10 wherein the selecting means generates for each  
 2 program a lowest bit rate representation having a peak bit rate not greater than  $C/P$  where  $C$  is the  
 3 total channel capacity in time  $T$  and  $P$  is the total number of programs.

1           17.    The system according to claim 10 wherein control information providing means  
 2 establishes quality measure in accordance with a peak signal-to-noise ratio (PSNR).

1           18.    The system according to claim 10 wherein the selecting means selects a  
 2 representation for each program which meets the constraint  $\sum_{p=0}^{P-1} r[p, n[p]] \leq C$  for all time

3 windows where:

4  $C$  is the total channel capacity available in time frame  $T$ ;

5  $P$  is the total number of programs;

6  $p \in (0, P-1)$ , is the index of a particular program;

7  $N[p]$  is the total number of representations of program  $p$ ;

8  $n[p] \in (0, N[p] - 1)$  is the index of a particular representation of program  $p$ ; and

9  $r[p, x]$  is the bit rate of representation  $x$  of program  $p$  during  $T$ .

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19. The system according to claim 18 wherein the selecting means chooses each program's representation  $n[p] \in (0, N[p]-1)$  to maximize the quality of the program  $p$  that had the minimum quality.

20. The system according to claim 10 wherein the selecting means selects the representation for each program such to maximize a sum of individual program qualities by solving:

$$\max_{n[p]} \sum_{p=0}^{P-1} q[p, n[p]]; \text{ subject to } \sum_{p=0}^{P-1} r[p, n[p]] \leq C$$

where,

$C$  is the total channel capacity available in time frame  $T$ ;

$P$  is the total number of programs;

$p \in (0, P-1)$ , is the index of a particular program;

$N[p]$  is the total number of representations of program  $p$ ;

$n[p] \in (0, N[p]-1)$  is the index of a particular representation of program  $p$ ;

$r[p, x]$  is the bit rate of representation  $x$  of program  $p$  during  $T$ ; and

$q[p, x]$  is the quality of representation  $x$  of program  $p$  during  $T$ .

21. The system according to claim 10 wherein the selecting means selects the representation for each program such to maximize a product of individual program qualities by solving:

$$\max_{n[p]} \prod_{p=0}^{P-1} q[p, n[p]]; \text{ subject to } \sum_{p=0}^{P-1} r[p, n[p]] \leq C$$

where,

$C$  is the total channel capacity available in time frame  $T$ ;

$P$  is the total number of programs;

$p \in (0, P-1)$ , is the index of a particular program;

$N[p]$  is the total number of representations of program  $p$ ;

$n[p] \in (0, N[p]-1)$  is the index of a particular representation of program  $p$ ;

$r[p, x]$  is the bit rate of representation  $x$  of program  $p$  during  $T$ ; and

$q[p, x]$  is the quality of representation  $x$  of program  $p$  during  $T$ .

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1           22.    The system according to claim 10 wherein a weighted average is applied to  
2 provide different classes of service for different viewers.

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